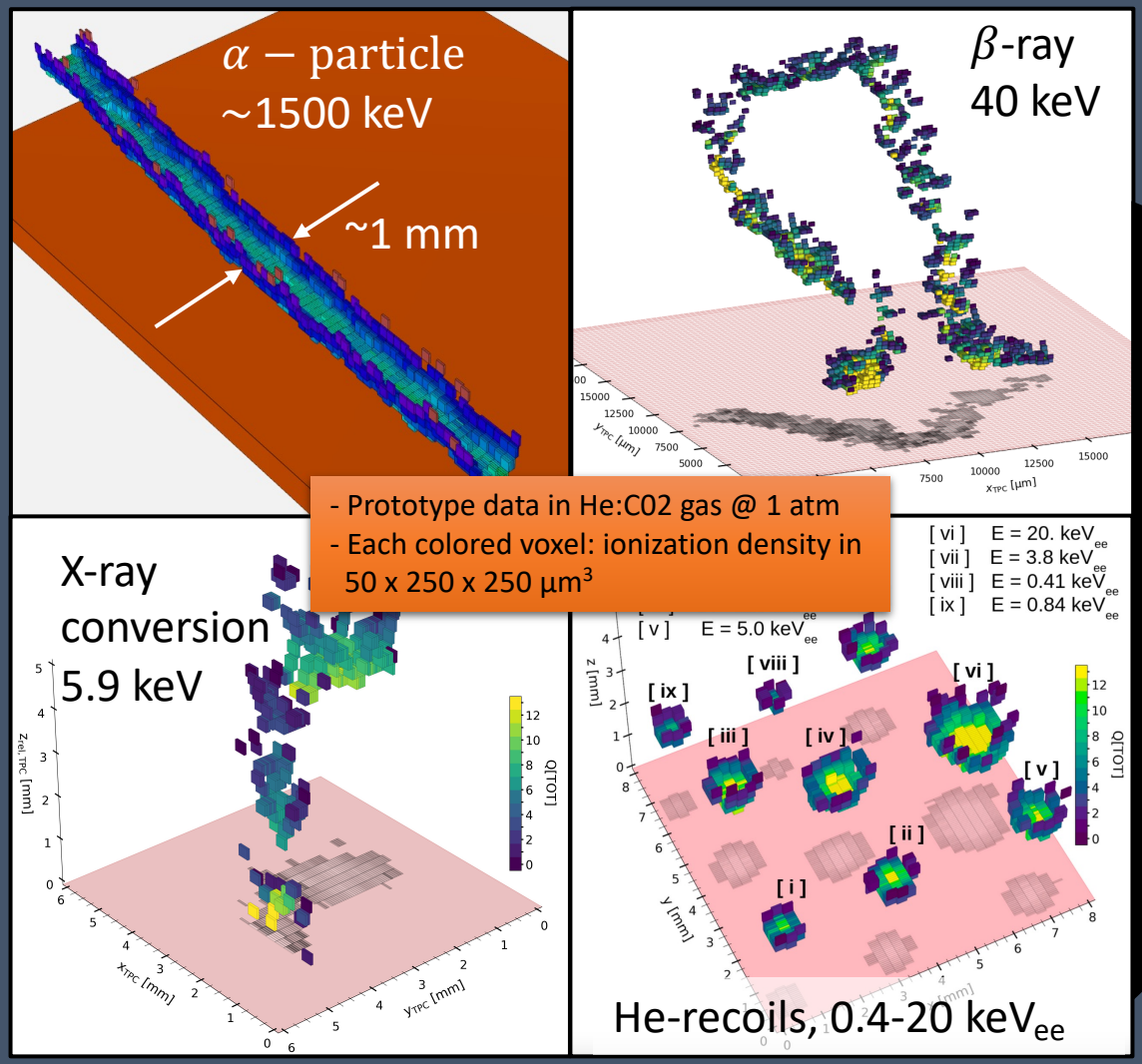
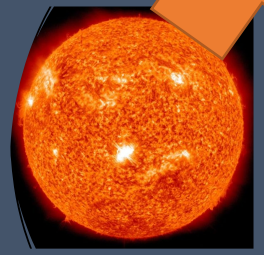
CYGNUS: New Physics Capabilities from Recoil Imaging



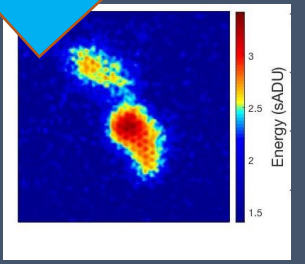
"recoil imaging": detection of detailed ionization topology in gas TPCs

Dark Matter Wind

Neutrinos from artificial sources



Astrophysical neutrinos



Exotic final states (e.g. Migdal effect)

- A Snowmass working group of 167 physicists considered the case for "recoil imaging" (arXiv:2203.05914)
- Topological and directional reconstruction of low-energy nuclear and electronic recoils enables new experiments

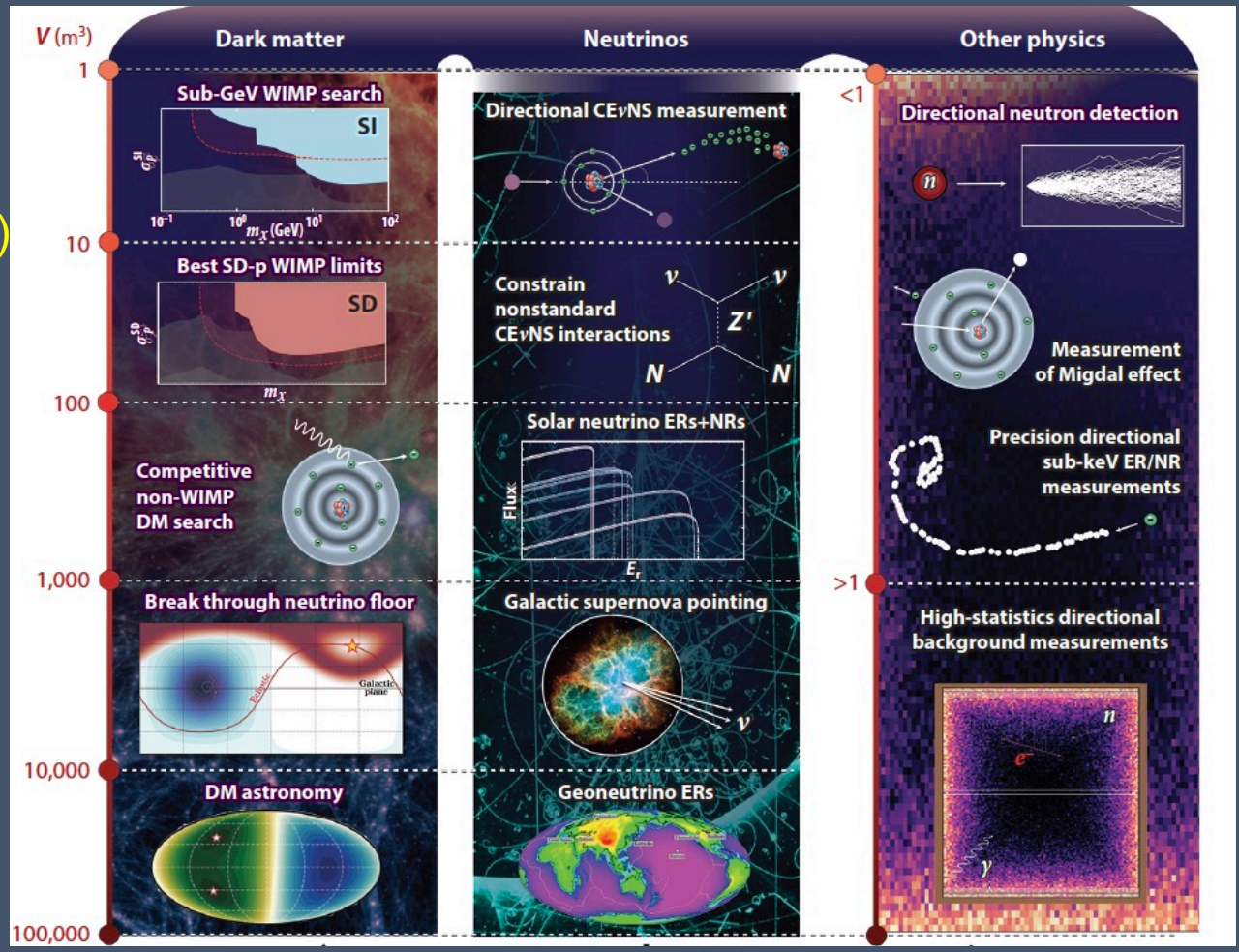
Opportunities for a 30+ year physics program

arxiv:2102.04596

Approx. volume of gas TPC required.
Expect 10 m^3 modules eventually

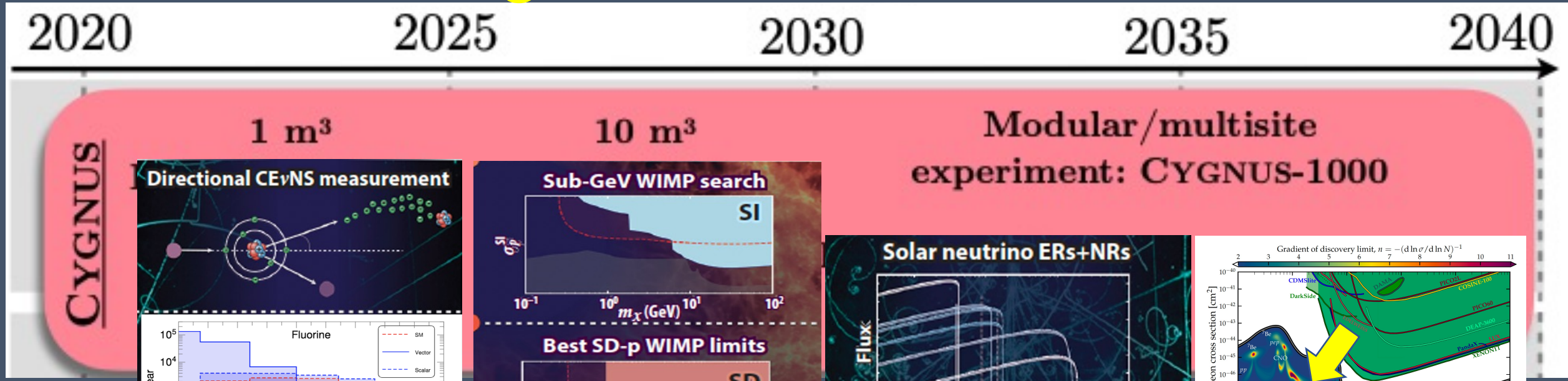
- Quenching factor and recoil physics (TUNL)
- Migdal Effect measurement
- Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) at ORNL (SNS) or Fermilab (NuMI and later LBNF)
- Competitive DM limits in SI and SD
- CEvNS and e-recoils from solar neutrinos
- Efficiently penetrating the LDM ν floor
- Observing galactic DM dipole
- Measuring DM particle properties and physics
- Geoneutrinos
- WIMP astronomy

Exposure, size



- New physics opportunities for each factor of 10 increase in exposure
- Both guaranteed measurements (yellow text) and novel, exciting searches --- across frontiers!

CYGNUS: US Program Vision & P5 Ask



Arxiv:2008.12587

SNS, Oak Ridge, TN
$1M
Directional BSM-search in CEvNS

SURF, Lead, SD
$5M
World-leading DM limits

International, multi-site
$50M, for 1000m³ in the U.S.
DM search in the neutrino fog!

- 3 years of R&D (5 universities, three national labs). Establish electron counting & 1-keV recoil directionality: $2M / year
- Directional BSM search in 1 m³ ν-scattering experiment, aboveground — $1M (hardware only)
- Radio-pure 10 m³ experiment, underground (DM) — $5M (hardware only)
- MIE for large-scale, underground observatory (solar neutrinos + DM below neutrino floor) — $50M (hardware only)